Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1.   (Currently Amended)   A haptic interface device to provide haptic interaction to a user manipulating a tool, the haptic interface device comprising:

an attachment point;

a plurality of cables coupled to the attachment point, the plurality of cables comprising a first, a second, a third, and a fourth length of cable, ~~each having a first and a second end, and each coupled at respective first ends to~~ extending from the attachment point;

a first tool translation effecter device having a first cable guide, a second tool translation effecter device having a second cable guide, a third tool translation effecter device having a third cable guide, and a fourth tool translation effecter device having a fourth cable guide, the first, the second, the third and the fourth cable guides ~~guide~~ positioned, relative to each other, such that each of the first, the second, the third, and the fourth cable guides occupies a vertex of a tetrahedron, each tool translation effecter device having coupled thereto ~~the second end of~~ a respective one of the first, the second, the third, and the fourth lengths of cable ~~cables~~ such that, as the attachment point moves, each of the first, the second, the third, and the fourth lengths of cables is retracted or paid out accordingly by the respective tool translation effecter device, each tool translation effecter device including controlling means for selectively varying an active tension on the respective length of cable;

metering means for metering each of the first, the second, the third, and the fourth length of cables as they are retracted and paid out; and

~~calculating means for calculating a force response vector to be applied to the attachment point at least in part on the basis of a position of the attachment point, as determined by a distance between each of the first, the second, the third, and the fourth cable guides and the attachment point, the calculating means is configured to calculate the force response vector~~

~~according to the equation $J = (A\tau - f) + \alpha[\tau]^2$ by adjusting τ such that J is close to or equal to zero, where τ is a scalar representing magnitudes of force to be applied to the first, the second, the third, and the fourth cables, $A\tau$ is the force response vector to be applied to the attachment point, f is a target force vector, and α is a stability coefficient.~~

<u>establishing means for establishing a respective distance between each of the first, the second, the third, and the fourth cable guides and the attachment point, the establishing means including a memory configured to receive and store, prior to a complete shutdown of the device, the respective distances between each of the first, the second, the third, and the fourth tool translation effecter devices and the attachment point, and to provide the stored distances during a startup procedure.</u>

2.   (Currently Amended) The haptic interface device of claim 1 wherein:

the controlling means of each of the first, the second, the third, and the fourth tool translation effecter devices includes a spool and a motor coupled to rotatably drive the spool, the motor and spool selectively operable to wind and unwind ~~the second end of~~ the respective <u>length of</u> cable; and

the metering means includes:

counting means for counting fractions of rotations of the spool of each of the first, the second, the third, and the fourth tool translation effecter devices<u>.</u>~~; and~~

~~compensating means for compensating for a change in ratio between changes in distance from each tool translation effecter device to the attachment point and angular rotation of the respective spool.~~

3.   (Currently Amended) The haptic interface device of claim <u>1</u> ~~57~~ wherein the establishing means includes a controller configured to direct the first tool translation effecter device to retract, during an initialization procedure, the first <u>length of</u> cable until the attachment point is at a selected position relative to the first tool translation effecter device.

4.   (Currently Amended) The haptic interface device of claim ~~58~~ 1 wherein the controlling means of each of the first, the second, the third, and the fourth tool translation effecter devices includes a rotatably driven spool, selectively operable to wind and unwind the respective length of cable, wherein the establishing means includes ~~respective~~ at least four brakes, each respective brake coupled to respective ones of the first, the second, the third, and the fourth tool translation effecter devices, and each respective brake configured to ~~lock each of the first, the second, the third, and the fourth tool translation effecter devices when electric current is removed therefrom, and a memory configured to receive and store, after current is removed from the brakes and prior to a complete shutdown of the device, the respective distances between each of the first, the second, the third, and the fourth tool translation effecter devices and the attachment point, and to provide the stored distances during a startup procedure~~ prevent rotation of the respective spool of the respective translation effecter device coupled thereto when actuated.

5.   (Currently Amended) The haptic interface device of claim 1 ~~57~~ wherein the establishing means includes a sensor configured to sense, independent of the first tool translation effecter device, a position of the attachment point relative to the first tool translation effecter device and wherein the establishing means includes means for calibrating the first, the second, the third and the fourth translation effecter devices based at least on the sensed position of the attachment point.

6.   (Currently Amended) The haptic interface device of claim ~~5~~ 1 wherein the establishing means includes means for reestablishing the ~~distance~~ respective distances from time to time during ~~operation~~ a period of time in which the first, the second, the third and the fourth tool translation effecter devices are continuously powered and includes means for calibrating the first, the second, the third and the fourth translation effecter devices during the period of time based at least on the respective reestablished distances.

7.   (Previously Presented) The haptic interface device of claim 1, further comprising:

a sensor array at the attachment point configured to provide signals corresponding to an orientation of the attachment point.

8.   (Original) The haptic interface device of claim 7 wherein the sensor array is configured to provide signals corresponding to roll, pitch, and yaw of the attachment point.

9.   (Currently Amended) A haptic interface device to provide haptic interaction to a user manipulating a tool, the haptic interface device comprising:

an attachment point configured to receive the tool and to be moved at least within ~~an n-dimensional~~ a workspace~~, in which "n" has a value of two (2) or three (3)~~;

a plurality of not more than four lengths of cables and a plurality of not more than four cable guides, each length of cable coupled ~~at a respective first end~~ to the attachment point and extending to a respective cable guide of the plurality of cable guides~~, and wherein the n-dimensional workspace is defined by n+1 cable guides of the plurality of cable guides~~;

~~a processor system configured to calculate a respective tension vector for each respective cable based at least on a mathematical optimization of an equation having at least a first term and a second term, the first term corresponding to a net vector having at least a calculated force response vector and the respective tension vectors for the respective cables as components thereof, the second term corresponding to a function with at least a respective magnitude of each of the respective tension vectors as arguments thereof, wherein the mathematically optimized equation is close to or equal to zero; and~~

a plurality of tool translation effecter devices ~~communicatively coupled to the processor system~~, each having ~~coupled thereto~~ a spool with an ~~a second~~ end of a respective one of the plurality of cables coupled thereto such that, as the attachment point moves relative to that tool translation effecter device, the cable coupled thereto is retracted or paid out accordingly, each tool translation effecter device configured to selectively vary an active tension on the cable

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coupled thereto ~~based at least on the calculated respective tension for the respective cable and to~~ ~~meter the cable as it is retracted and paid out~~; and

a first, a second, a third, and a fourth brake, each respective brake coupled to a respective tool translation effecter device of the first, the second, the third, and the fourth tool translation effecter devices and configured to prevent rotation of the respective spool of the respective tool translation effecter device having the respective brake coupled thereto while the haptic interface device is powered down.

10-11. (Canceled)

12.   (Currently Amended) A haptic device for operation by a user, comprising:

a user interface tool configured to be manipulated by the user and moved within a volume of space;

a first, a second, a third, and a fourth tool translation effecter device, each tool translation effecter device including a respective cable guide component coupled to a support structure in positions such that the respective cable guide components define between them a tetrahedron within the volume of space, each of the tool translation effecter devices further including a respective spool, a respective motor, and a respective encoder configured to provide a signal corresponding to rotation of the respective spool; and

~~a first, a second, a third, and a fourth cable each having a respective first and a~~ ~~respective second end, the first end of each of the first, the second, the third, and the fourth~~ a plurality of cables coupled to the user interface tool and comprising at least a first segment of cable, a second segment of cable, a third segment of cable and a fourth segment of cable extending from the user interface tool, and ~~the second~~ wherein an end of each of the first, the second, the third, and the fourth ~~cables~~ segments of cable are wound and unwound on the spool of a respective one of the tool translation effecter devices, each of the motors operable to drive the respective spool ~~to selectively apply active tension to the respective cable; and~~

~~a processor system coupled to the first, the second, the third, and the fourth tool~~ ~~translation effecter devices being configured to calculate tension vectors corresponding to active~~

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~~tensions applied to the respective cables based at least on a mathematical optimization of a mathematical equation having at least a first term and a second term, the first term including a net vector having a calculated force vector and the calculated tension vectors as components thereof, and the second term including a function having a respective magnitude of each of the calculated tension vectors as arguments thereof, wherein the mathematically optimized equation is close to or equal to zero, and wherein the active tensions applied to the respective cables yield an actual force vector applied to the user interface tool that corresponds to the calculated force vector.~~

<u>a first, a second, a third, and a fourth brake, each brake coupled to a respective tool translation effecter device of the first, the second, the third, and the fourth tool translation effecter devices and configured to prevent rotation of the respective spool of the respective tool translation effecter device having the brake coupled thereto while the haptic interface device is powered down.</u>

13.   (Currently Amended) The haptic device of claim ~~74 wherein the~~ <u>12,</u> <u>comprising a</u> sensor array ~~is~~ configured to detect roll, pitch, and yaw of the user interface tool.

14.   (Currently Amended) The haptic device of claim 12<u>,</u> ~~wherein the~~ <u>comprising a</u> processor system <u>that</u> receives the signals from the respective encoders, the processor system configured to determine movement of the user interface tool therefrom~~, to calculate the force vector based at least on a position of the user interface tool~~.

15.   (Currently Amended) The haptic device of claim 14 wherein the processor system is configured to compensate for changes in effective diameter of the spools of the first, the second, the third, and the fourth tool translation effecter devices due to ~~changing thickness of cable on each of the spools as~~ the respective cable <u>being</u> ~~is~~ wound and unwound from the respective spool.

16.   (Canceled)

17. (Currently Amended) The haptic device of claim ~~12~~ 14 wherein the processor system is configured to establish an initial position of the tool by retracting, in turn, each of the first, the second, the third, and the fourth segments of cable ~~cables~~ to a known length position.

18. (Currently Amended) A haptic device for operation by a user, comprising:

a support structure;

a port coupled to the support structure;

a user interface tool configured to be manipulated by the user and moved within a volume of space, the user interface tool includes a tool shaft having a first and a second end, the tool shaft passing through the port such that the tool shaft pivots at the port and manipulation of the second end of the tool shaft is reflected in movement of the first end of the tool shaft;

a first, a second, a third, and a fourth tool translation effecter device, each coupled to the support structure in positions such that the first, the second, the third, and the fourth tool translation effecter devices define between them a tetrahedron within the volume of space, each of the tool translation effecter devices including a respective spool and a respective encoder configured to provide a signal corresponding to rotation of the respective spool; and

a first, a second, a third, and a fourth length of cable ~~each having a respective first and a respective second end, the first end of each of the first, the second, the third, and the fourth cables,~~ each of the first, the second, the third, and the fourth length of cable being coupled to the first end of the tool shaft and ~~the second end of~~ each of the first, the second, the third, and the fourth lengths of cable being ~~cables~~ wound and unwound on the spool of a respective one of the tool translation effecter devices.

19. (Previously Presented) The haptic device of claim 18, further comprising:

a first sensor located at the port and coupled to the tool shaft, and configured to detect rotation of the user interface tool around an axis.

20.   (Previously Presented) The haptic device of claim 18, further comprising:

a first sensor configured to detect rotation of the user interface tool around an axis, and a second sensor coupled to the second end of the tool shaft and configured to detect gripping force exerted by the user.

21.   (Original) The haptic device of claim 18 wherein the second end of the tool shaft is configured to provide for the user a simulation of a selected tool.

22.   (Original) The haptic device of claim 21 wherein the selected tool is formed as one of a stylus, a pen, a pliers, a wrench, a forceps, a scalpel, an endoscope, or an arthroscope.

23.   (Original) The haptic device of claim 18, further comprising:

a feedback device coupled to the tool shaft and configured to selectively apply rotational force to the tool shaft.

24.   (Original) The haptic device of claim 23 wherein the feedback device is located at the port.

25.   (Original) The haptic device of claim 18, further comprising:

a feedback device coupled to the second end of the tool shaft and configured to selectively resist gripping force exerted by the user.

26.   (Previously Presented) The haptic device of claim 14 wherein the processor system is configured to maintain a virtual environment within which the user interface tool is operated, and to apply the actual force vector as feedback from the virtual environment to the user interface tool.

27.   (Currently Amended) The haptic device of claim 12, further comprising:

a remote tool[[,]]; and wherein

the a processor system is in communication with the remote tool and configured

to control operation of the remote tool in accordance with the movement and orientation of the

user interface tool.

28.   (Currently Amended) The haptic device of claim 27 wherein the

processor system is configured to apply the an actual force vector as feedback from the remote

tool to the user interface tool.

29.   (Previously Presented) A method, comprising:

applying a selectively variable active tension to each of a plurality of cables

having respective first and second ends, each of the plurality of cables coupled at its respective

first end to a tool, and at its respective second end to a respective anchor point;

measuring a change of cable length between the tool and each respective anchor

point;

establishing an initial length of cable between the tool and each of the anchor

points;

locking, during a shutdown procedure, each of the plurality of cables at the

respective anchor point;

storing, after the locking and before completing the shutdown procedure, a value

indicative of a known length of each of the cables in a memory; and

recovering the value indicative of the known length of each of the cables from the

memory during a startup procedure.

30.   (Currently Amended) The method of claim 29 wherein establishing an

initial length of cable comprises moving the tool in turn to each vertex of the anchor points a

tetrahedron such that the length of cable between the tool and the respective anchor point the

respective vertex is effectively zero, wherein a respective cable guide is positioned at each of the vertices of the tetrahedron.

31-32. (Canceled)

33.   (Previously Presented) The method of claim 29 wherein establishing an initial length of cable comprises:

tracking a position of the tool independent of the measuring; and

correlating the position of the tool with known positions of the anchor points.

34-37. (Canceled)

38.   (Currently Amended) A method of operating a cable based haptic interface device having four segments of cable and a specified calibration point, comprising:

~~selectively applying active tension to each of four cables,~~ during a calibration of a cable based haptic interface device, positioning a tool having four segments of cable coupled thereto at a specified single calibration point from which respective reference lengths of each of the four segments of cable is known, each segment of cable ~~having a first end~~ coupled to ~~a~~ the tool and having a respective length extending from the tool ~~first end~~ to a respective vertex of a tetrahedron such that, as the tool is moved closer to any respective vertex of the tetrahedron, the respective length of the segment of cable extending from the ~~respective first end~~ tool to the respective vertex is drawn in, thereby decreasing the respective length of the respective segment of cable, and as the tool is moved away from any respective vertex of the tetrahedron, the respective length of the segment of cable extending from the ~~respective first end~~ tool to the respective vertex is fed out, thereby increasing the respective length of the respective segment of cable;

establishing the respective length of each of the four segments of cable based at least on the tool being positioned at the calibration point and on the respective reference lengths of each of the four segments of cable;

selectively applying active tension to each of the four segments of cable;

tracking changes in length of each of the four ~~cables~~ segments of cable;

deriving a change of position of the tool on the basis of tracked changes in length of each of the four ~~cables~~ segments of cable.~~; and~~

~~optimizing, to be close to zero, an equation having at least a first term and a second term, the first term including a net vector having as components thereof a selected force vector that corresponds to an actual response feedback force vector applied to the tool and calculated target tension vectors corresponding to active tensions applied to each of the four cables, and second term including at least a function having at least magnitudes of the calculated target tension vectors as arguments thereof.~~

39.   (Previously Presented) The method of claim 38, comprising measuring rotation of the tool about one or more of three mutually perpendicular axes.

40-41. (Canceled)

42.   (Previously Presented) The haptic device of claim 13, further comprising a processor system coupled to receive information from the sensor array and coupled to receive the signals from the respective encoders, the processor system configured to determine movement and orientation of the tool therefrom.

43-48. (Canceled)

49.   (Previously Presented) The haptic interface device of claim 9 wherein the plurality of tool translation effecter devices includes at least a first, a second, a third, and a fourth tool translation effecter device, each of the first, the second, the third, and the fourth tool translation effecter devices having a respective cable guide of the plurality of cable guides, and where the respective cable guides are positioned relative to each other such that each respective cable guide occupies a vertex of a tetrahedron.

50.   (Canceled)

51.   (Previously Presented) The haptic interface device of claim 9, further

comprising:

establishing means for establishing, during an initialization procedure, a distance

between each of the tool translation effecter devices and the attachment point.

52.   (Currently Amended) The haptic interface device of claim ~~59~~ 51 wherein

~~the~~ the establishing means includes a sensor array is configured to provide signals corresponding

to each of a roll, a pitch, and a yaw of the tool.

53.   (Canceled)

54.   (Previously Presented) The haptic device of claim 12 wherein the device

comprises no more than four cables.

55-57. (Canceled)

58.   (Currently Amended) The haptic interface device of claim 1 ~~57~~ wherein

the establishing means comprises a calibration point at which the attachment point can be

positioned, and from which the respective distances between each of the first, the second, the

third, and the fourth cable guides and the attachment point are known.

59.   (Previously Presented) The haptic interface device of claim 9, comprising

a sensor array associated with the attachment point and configured to provide signals

corresponding to at least one of roll, pitch, and yaw of the tool.

60.   (Canceled)

61.   (Currently Amended) The method of claim 38, comprising selecting a value of active tension applied to each of the four <u>cable segments</u> ~~cables~~ on the basis of the selected force vector that corresponds to the actual response feedback force vector to be applied to the tool.

62.   (Currently Amended) A method of operating a haptic device having a tool coupled to a first end of a first cable, comprising:

as a tool is moved in a first direction, winding a first cable having a first end coupled to the tool onto a spool;

as the tool is moved in a second direction which is opposite the first direction, unwinding the first cable from the spool;

~~calculating a force response vector based at least on a current position of the attachment point;~~

~~calculating an optimization of a function of having at least a first term and a second term, the first term including the calculated force response vector and a calculated tension vector for the first cable, the second term including a function having at least a magnitude of the calculated tension vector for the first cable as an argument thereof, wherein the optimized function is close to or equal to zero; and~~

~~selectively applying active tension to the first cable based at least on the calculated tension vector.~~

<u>locking, during a shutdown procedure, the first cable at the spool;</u>

<u>storing a value indicative of a known length of the first cable in a memory; and</u>

<u>recovering the value indicative of the known length of the first from the memory during a startup procedure.</u>

63.   (Currently Amended) The method of claim 62 wherein the first cable is one of a plurality of cables having respective first and second ends, the first ends coupled to the tool and the respective second ends coupled to respective spools, and further comprising:

for each respective cable of the plurality of cables,

winding the respective cable onto a respective spool as the tool is moved in a respective first direction,

unwinding the respective cable from the respective spool as the tool is moved in a respective second direction which is opposite the respective first direction,

tracking a respective paid-out cable amount for each respective cable by counting fractional rotations of each of the respective spools,[[;]] and

limiting tracking errors introduced by changes in an effective diameter of the respective spool of the respective cable as the effective diameter changes in response to the respective cable being wound and unwound therefrom.

64.   (Previously Presented) The method of claim 62 wherein the first cable is one of three cables, each cable having a respective first end coupled to the tool and providing a plane in which the tool has freedom to move, the plane defined by three cable guides, wherein each respective cable extends from the tool and to a respective one of the three cable guides.

65.   (Previously Presented) The method of claim 62 wherein the first cable is one of four cables, each cable having a respective first ends coupled to the tool and providing a volume of space in which the tool has freedom to move defined four cable guides positioned at respective vertices of a tetrahedron, wherein each respective cable extends from the tool and to a respective one of the four cable guides.

66-79. (Canceled)

80.   (New) The haptic interface device of claim 1 wherein controlling means of each of the first, the second, the third, and the fourth tool translation effecter devices includes a rotatably driven spool, selectively operable to wind and unwind the second end of the respective cable;

wherein metering means includes at least four encoders, each respective encoder arranged to provide signals corresponding to rotation of a respective spool of a respective translation effecter device; and

wherein establishing means includes at least four brakes, each respective brake coupled to respective ones of the first, the second, the third, and the fourth tool translation effecter devices, and each respective brake configured to lock in position a respective encoder when actuated.

81.   (New) The haptic interface device of claim 9 wherein each respective tool translation effecter device of the plurality of tool translation effecter devices includes a respective encoder configured to provide a signal corresponding to rotation of the respective spool of the respective tool translation effecter device, and wherein each respective brake selectively locks in position the respective encoder of the respective tool translation effecter device having the respective brake coupled thereto when actuated.

82.   (New) The haptic interface device of claim 12 wherein each respective brake selectively locks in position the respective encoder of the respective tool translation effecter device having the respective brake coupled thereto when actuated.

83.   (New) The method of claim 38 wherein positioning a tool having four cables coupled thereto at a specified single calibration point from which respective reference lengths of each of the four cables is known includes manually positioning the tool at the specified single calibration point.

84.   (New) A method of operating a cable based haptic device having a plurality of cables and a plurality of cable guides, comprising:

for each segment of cable coupled to a tool and extending between the tool and a respective cable guide of a plurality of cable guides and further extending therefrom to a respective anchor point of a plurality of anchor points, applying a selectively variable active tension to the respective segment of cable;

measuring a change of length of the segment of cable between the tool and each respective cable guide of the plurality of cable guides;

establishing an initial length of cable between the tool and each cable guide of the plurality of cable guides;

locking, during a shutdown procedure, each of the plurality of segments of cable at the respective anchor point;

storing, after the locking and before completing the shutdown procedure, a value indicative of a known length of each of the segments of cable in a memory; and

recovering the value indicative of the known length of each of the segments of cable from the memory during a startup procedure.

85.   (New) The method of claim 84 wherein establishing an initial length of cable comprises moving the tool in turn to each vertex of a tetrahedron such that the length of cable between the tool and the respective the respective vertex is effectively zero, wherein a respective cable guide is positioned at each of the vertices of the tetrahedron.

86.   (New) The method of claim 84 wherein establishing an initial length of cable comprises:

tracking a position of the tool independent of the measuring; and

correlating the position of the tool with known positions of the anchor points.